SECTION 5

ROADS AND DRAINS

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SECTION 5

ROADS AND DRAINS

5.1 Definitions

The words like Contract, Contractor, Engineer (synonymous with Engineer-in-charge), Drawings, Employer, Government, Works and Work Site used in these Specifications shall be considered to have the meaning as understood from the definitions of these terms given in the General Conditions of Contract.

The following abbreviations shall have the meaning as set forth below:

MORTH	:	Ministry of Road Transport and Highways
IRC	:	Indian Roads Congress
IS	:	Indian Standard published by the Bureau of Indian Standards
GSB	:	Granular Sub Base
WMM	:	Wet Mix Macadam
BM	:	Bituminous Macadam
BC	:	Bituminous Concrete
CBR	:	California Bearing Ratio
AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing and Materials
BS	:	British Standard published by the British Standards Institution

The various elements in the cross-section of a road (STP) referred to in these Specifications are shown in the cross-sections in **Fig. 5-1**.

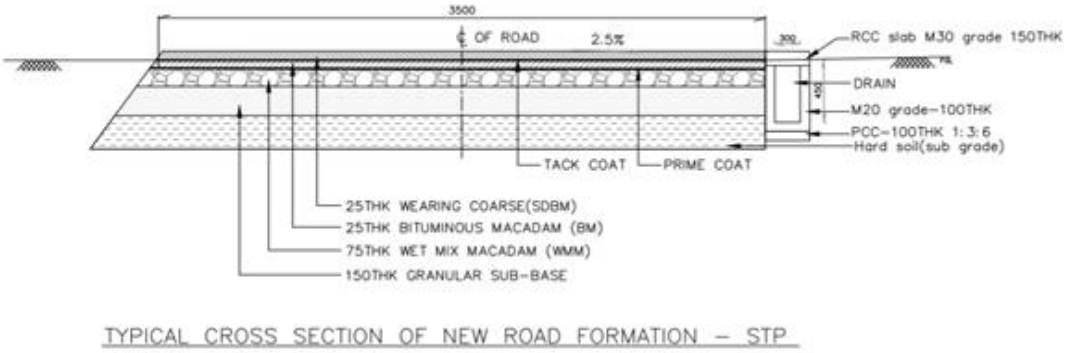

Fig. 5-1: Proposed Typical Cross Section of the Road (STP)

5.2 Applicable Codes and Specifications

The following specifications, standards and codes are referred to in this part.

IS : 460 (Parts 1 to 3) : Specification for Test sieves
IS : 1077 : Common burnt clay building bricks - Specification
IS : 1124 : Method of test for determination of water absorption, apparent specific gravity and porosity of natural building Aggregates / stones
IS : 1195 : Specification for Bitumen Mastic for Flooring
IS : 1196 : Code of Practice for Laying Bitumen Mastic Flooring
IS : 1834 : Specification for Hot Applied Sealing Compounds for Joints in Concrete
IS : 2386 (Parts 1 to 8) : Methods of test for aggregates for concrete
IS : 2720 (Part 5) : Method of Test for Soils for determination of Liquid and plastic limit.
IS : 6241 : Method of test for determination of stripping value of road aggregates.
IRC : 16 : Specification for priming of Base Course with Bituminous Primers.
IRC : 17 : Tentative specification for Single Coat Bituminous Surface Dressing
IRC : 19 : Standard specifications and code of practice for water bound macadam
IRC : 29 : Specification for bituminous concrete (Asphaltic Concrete) for road pavement.
MORTH Specifications : Ministry of Road Transport and Highways Specifications for Road and Bridge works
SECTION-100 : GENERAL
SECTION-300 : EARTHWORK
SECTION-401 : GRANULAR SUB BASE
SECTION-406 : WET MIX MACADAM
SECTION-504 : BITUMINOUS MACADAM
SECTION-507 : BITUMINOUS CONCRETE

5.3 Road Configuration

The roads shall be installed in layers as per Drawing over the back fill as per concerned sections of MORTH. In Plant premise all the motorable road width is minimum 3.5m.
On laying of Pumping main/sewer lines in the trenches, the roads shall be restored to its original condition in layers as per Drawing over the back fill as per concerned sections of MORTH

Technical specification:

a) Backfill over the water lines / sewer lines to the desired level as per drawing and specification.
b) Approved soil compacted in layers as per drawing, using soil deposited at site from road cutting and excavation to achieve compaction level Table 300-2 and Section 301 of MORTH Technical specification.
c) Layer of sand / stone dust as per drawing to achieve 97% relative compaction of laboratory dry density to meet requirement of table 300-2 of MORTH specification.

d) Granular Sub base as per section 401 of MORTH specification.
e) Wet mix macadam (WMM) as per section 406 of MORTH specification.
f) Bituminous macadam (BM) as per section 504 of MORTH specification.
g) Bituminous concrete (BC) as per section 507 of MORTH specification.

5.4 Materials

5.4.1 General

All materials shall be obtained from local sources and shall conform to technical specifications and be subject to Engineer's approval prior to use.

5.4.2 Approved soil for Subgrade / Embankment

The materials used in embankments, subgrades and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/ subgrade.

The Contractor shall carry out the excavation in such a manner that the acceptable materials are excavated separately for use in backfill/restoration works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

It shall be ensured that the subgrade material when compacted to the density requirements as in **Table 5.1** (As per Table 300-2 of MORTH specification) shall yield the design CBR value of the subgrade.

Table 5.1: Compaction requirement for Subgrade
(As per Table 300-2 of MORTH Specification)

Type of work/material		**Relative compaction as % of max. lab dry density as per IS: 2720 (Part 8)**
1	Subgrade and earthen shoulders	Not less than 97
2	Embankment	Not less than 95

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

i) The values of Maximum Dry Density and Optimum Moisture Content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
ii) A graph of density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

iii) The Dry density-moisture content - CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall form the basis for compaction.

5.4.3 Granular Sub Base

The material to be used for the work shall be natural sand, murum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to grading-iii given in **Table 5.2: Gradation for coarse graded granular Sub base.** (As per Table 400-1 of MORTH Specifications).

The CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions, which shall be taken as being the density relating to a uniform air, voids content of 5 per cent.

Table 5.2: Gradation for coarse graded granular Sub base.
(As per TABLE 400–1 of MORTH Specification)

IS Sieve	Percent by weight passing the IS Sieve		
Designation	**Grading I**	**Grading II**	**Grading III**
75.0 mm	100	-	-
53.0 mm	80-100	100	100
26.5 mm	55 - 90	70-100	55-75
9.50 mm	35-65	50-80	-
4.75 mm	25-55	40-65	10-30
2.36 mm	20-40	30-50	-
0.425 mm	10-15	10-15	-
0.075 mm	<5	<5	<5
CBR Value(Minimum)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

5.4.4 Coarse Aggregates

Coarse aggregate, stone chippings shall consist of natural or crushed stone, clean, hard, tough, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt, salt, alkali, vegetable matter, adherent coatings, organic and other objectionable matter, and shall conform to the physical requirements given in **Table 5.3** and **Table 5.4** hereunder, as applicable. Aggregate for bituminous

wearing courses shall in addition have good hydrophobic properties i.e. capacity of retaining the film of bituminous material applied to the stone in all weather conditions and especially in wet conditions. Basalt, dolerites are good in this respect; granite, quartzites are comparatively poor.

Table–5.3: Physical Requirements of Coarse Aggregate for Wet Mix Macadam (WMM

Sl. No	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	40 percent (max.) 30 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part – IV) Or IS:5640***
2.	Flakiness Index **	15 percent (max.)	IS:2386 (Part I)
3.	Combined Flakiness and Elongation Indices**	35 percent (max.)	IS:2386 (Part I)

(*) Aggregate may satisfy requirements of either of two tests.

(**) Requirements of flakiness index shall be enforced only in case of crushed broken stone.

(***) Aggregates like brick, metal, kankar, laterite etc., which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS: 5640.

Table – 5.4: Physical Requirements of Coarse Aggregates for Dense Bituminous macadam (BM) (As per Table 500-8 of MORTH Specification)

Sl. No.	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	35 percent (max.) 27 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part –
2.	Combined Flakiness and Elongation Indices (Total) **	35 percent (max.)	IS:2386 (Part I)
3.	Coating and Stripping of Bitumen Aggregate Mix	Min. Retained coating 95%	IS:6241
4.	Water Absorption	2 percent (max.)	IS:2386 (Part-III)
5.	Soundness Loss with Sodium Sulphate – 5 cycles Loss with Magnesium Sulphate – 5 cycles	 12 percent (max.) 18 percent (max.)	 IS:2386 (Part-V)

(*) Aggregate may satisfy requirements of either of two tests

(**) Requirement of flakiness index shall be enforced only in case of crushed broken stone

5.4.5 Murum/Kankar/Gravel

Murum shall contain low plasticity binder material mixed with hard granular particles such as sand and/or gravel. Murum shall be sound and hard of a quality not affected by weather, to be screened at

the quarry and free from all impurities. Large lumps shall all be broken at the quarry and murum delivered at site must pass in every direction through a 63 mm ring. Murum shall not contain more than 5% to 8% of fines passing a 75 micron sieve.

Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt, organic and deleterious matter. It shall be hard, tough, dense and shall not contain particles bigger than 12 mm and more than 10 percent silt.

5.4.6 Sand / Stone Dust

The sand / Stone dust shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorized sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5. The Sand used shall be coarse, sharp, gritty, clean, granular material. Only material passing through 4.75 mm sieve and retained on 75 micron sieve shall be used.

The sand / Stone dust / fine aggregates shall conform to grading requirement in Table 5.5

Table 5.5: Gradation requirement of Sand / Fine aggregates

(As per Table 1000-2 of MORTH Specifications)

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

Note: When the grading falls outside the limits of any particular grading zone of sieves other than 600-micron IS Sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. However for crushed stone sand, the permissible limit on 150-micron IS Sieve is increased to 20 percent. Reference shall be made to clause: 4.3 of IS: 383.

5.4.7 Bituminous Materials

Bituminous materials shall conform to IS: 73, IS: 215, IS: 217 or IS: 454 as applicable and be of the grade specified.

Table 5.6: Physical requirements of Coarse aggregates for Bituminous concrete (BC). (As per TABLE 500-16: MORTH specifications)

PROPERTY	TEST	SPECIFICATION	METHOD OF TEST
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve.	IS: 2386 Part I
Particle shape	Flakiness and Elongation Index	Max 30% (Combined)2	IS: 2386 Part I
Strength	Los Angles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	IS: 2386 Part IV
Polishing	Polished Stone Value	Min 55	BS: 812-114
Durability	Soundness: Sodium Sulphate or Magnesium Sulphate	 Max 12% Max 18%	IS: 2386 Part V
Water Absorption	Water absorption	Max 2%	IS: 2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Minimum retained coating 95%.	IS: 6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

* If the minimum retained Tensile strength test falls below 80%, use of anti-stripping agent is recommended to meet the requirement.

5.5 Earth work

5.5.1 Earthwork in Excavation

In general the excavation shall be in accordance to Specifications specified elsewhere.

Profiles of road excavation shall be laid at 50 m intervals or as specified in Drawings to conform to the required alignment, sections, grades and side slopes and the lines of cuts shall be clearly marked.

Contractor shall on no account excavate beyond the slopes or below the specified grade unless so approved by the Engineer in writing. If excavation is done below the specified level or outside the section the Contractor shall be required to fill up with approved materials, in layers of 150 to 200 mm, watered and compacted as specified for the subgrade.

The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections as shown in the drawings or approved by Engineer.

5.5.2 Earthwork in Subgrade

The Subgrade shall be formed of approved soil excavated from road trenches and stacked separately.

Profiles of subgrade shall be set up with stout poles to mark the centre and edges of the formation with the top levels of formation clearly marked by paint or cut and the slopes with strings and pegs at every 10 metres on straight portions.

Subgrade material shall be placed in successive horizontal layers of 200 mm depth extending to the full width of the Subgrade / trench to allow compaction of the full specified section to 150 mm using mini rollers / tampers / plate vibrators till the soil is evenly compacted to 95% of Proctor density with 2% variation in optimum moisture content. Before placing the next layer of 200 mm the surface of the underlayer shall be moistured and scarified with pick axes or spades to provide a satisfactory bond with the next layer. The next layer shall also be compacted to 150 mm to the full width of the trench section till the soil is evenly compacted to 95% of Proctor density with 2% variation in optimum moisture content.
When boulders, broken stones and similar hard materials are mixed up with the embankment materials care shall be taken to see that they are distributed uniformly into the bank and that no hollows are left near them. No stone or hard material shall project above the top of any layer. Each layer of embankment shall be watered, levelled, and compacted as specified before the succeeding layer is placed. The surface of the embankment shall at all times during construction be maintained at such a cross fall as will shed water and prevent ponding.

If the soil contains less than the optimum moisture, water shall be added to the loose layers of the subgrade to bring the moisture uniformly upto requirement. If the material contains more than the required moisture it shall be allowed to dry until the moisture is reduced to the required extent. The moistured/dried loose layers shall be compacted with a vibratory roller / mini roller / plate vibrator/ tampers to achieve the desired compaction level of 95% of Proctor density.

5.6 Compaction with Sand / stone dust

In order to achieve better compaction and a compacted surface before laying the GSB layer, two layers of sand / stone dust shall be laid and compacted to 150 mm each.

5.7 Preparation of Granular Sub-base (GSB)

Spreading and Compacting: The granular sub base material of **grade-iii** as specified in **Table 5.2: Gradation for coarse graded granular Sub base** (As per Table 400–1 of MORTH Specifications) shall be spread on the prepared sub grade maintaining the required slope and grade during the operation or other means as approved by the Engineer or as per applicable MORTH Specifications. The work shall be done as per Clause 401 MORTH V revision and as per BOQ provisions.

When the sub base material consists of combination of materials mentioned in clause 401.2, mixing shall be done mechanically by the mix in- place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small – sized jobs. The equipment used for mix-in-place construction shall be rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS: 2720 (part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material.

All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re – compacted.

5.8 Wet mix Macadam Course (WMM)

The GSB layer surface over which Wet mix Macadam (WMM) is to be laid shall be prepared to the specified grade and camber and made free of dust and other extraneous material.

Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. WMM. sub-base course of specified thickness shall be provided. The course aggregate for this shall conform to requirements in **Table-5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM)** (As per Table 400-13 of MORTH Specifications).

Table – 5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM) (As per Table 400-13 of MORTH Specifications)

IS Sieve Designation	Percent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95 – 100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

5.8.1 Preparation of WMM layer

Preparation of mix: Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

Spreading of mix: Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade /sub- base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used so as to achieve the specified slope and grade. The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

Compaction: After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable vibratory roller. The speed of the roller shall not exceed 5 km/h. The work shall be done as per Clause 406 MORTH V revision and as per BOQ provisions.

5.9 Primer coat

Primer: The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. Surface of low porosity; such as wet mix macadam. The primer shall be bitumen emulsion.

Primer viscosity: The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in **Table-5.8: Requirement of Viscosity and quantity of Liquid bituminous Primer** (As per Table 500-1 of MORTH Specifications).

Table-5.8: Selection Criteria for Viscosity-Graded (VG) Paving Bitumens based on Climatic conditions (As per Table 500-1 of MORTH Specifications)

Lowest Daily Mean Air Temperature, ^{o}C	**Highest Daily Mean Air Temperature, ^{o}C**		
	Less than 20 ^{o}C	20 to 30 ^{o}C	More than 30 ^{o}C
More than -10 ^{o}C	VG-10	VG-20	VG-30
-10 ^{o}C or lower	VG-10	VG-10	VG-20

Providing and applying primer coat with S.S. bitumen emulsion on prepared surface of granular base such as WMM including cleaning of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means complete as per specifications The work shall be done as per Clause 502 MORTH V revision and as per BOQ provisions.

Preparation of road surface: The surface to be primed shall be prepared in accordance with Clauses 501.8. and 902 as appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

Application of bituminous primer: The viscosity and rate of application of the primer shall be as specified in the Contract, or as determined by site trials carried out as directed by the Engineer. The bituminous primer shall be sprayed uniformly in accordance with Clause 501 of MORTH specifications. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Curing of primer and opening to traffic: A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with an application of sand, using the minimum quantity possible. The work shall be done as per BOQ provisions.

5.10 Tack Coat

Over the primed surface, a tack coat should be applied in accordance with Clause 503 of MORTH Specifications.

The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the Contract or as directed by the Engineer.

The tack coat distributor shall be a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clauses 501.8 and 902 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract then it shall be at the rate specified in **Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat** (As per Table 500-5 of MORTH Specifications).

Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat (As per Table 500-5 of MORTH Specifications).

Sl No	Type of Surface	Quantity of Liquid bituminous material in Kg per sq.m.area
i)	Normal bituminous surfaces	0.20 to 0.30
iii)	Granular surfaces treated with primer	0.25 to 0.30
iv)	Non bituminous surfaces Cement concrete pavement	0.30 to 0.35

The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C. The work shall be done as per Clause 503 MORTH V revision and as per BOQ provisions.

5.11 Bituminous Macadam

The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73.

Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in **Table-5.10: Composition of Bituminous macadam (BM)** (As per Table 500-7 of MORTH Specification) for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-7.

Table-5.10: Composition of Bituminous macadam (BM)

(As per Table 500-7 of MORTH Specification)

Mix designation Nominal aggregate size Layer thickness	Grading 1 40mm 80 -100mm	Grading 2 19 mm 50 - 75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36

2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight of total mixture[1]	3.1 - 3.4	3.3 - 3.5
Bitumen grade	35 to 90	35 to 90

5.11.1 Preparation of the Base:

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 501.8 and 902.3 as appropriate, or as directed by the Engineer.

5.11.2 Preparation and transportation of the Mixture:

The provisions of Clauses 501.3 and 501.4 shall apply.

5.11.3 Spreading: The provisions of Clauses 501.5.3 shall apply.

5.11.4 Compaction:

Compaction shall be carried out in accordance with the provisions of Clause 501.6 and 501.7. The details of mixing, laying and rolling temperature of BM mix is as indicated in **Table-5.11:** Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree celcius) (As per Table 500-2 of MORTH Specifications)
Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 903.

Table-5.11: Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree celcius) (As per Table 500-2 of MORTH Specifications)

Bitumen Viscosity grade	Bitumen Temperature (°C)	Aggregate Temperature (^{o} C)	Mixed Material Temperature(°C)	Rolling Temperature (^{o} C)	Laying Temperature (^{o} C)
VG-40	160-170	160-170	160-170	100 Min	150 Min
VG-30	150-165	150-170	150-165	90 Min	140 Min
VG-20	145-165	145-170	145-165	85 Min	135 Min
VG-10	140-160	140-165	140-160	80 Min	130 Min

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before opening to any traffic. The seal coat in

such cases shall be considered incidental to the work and shall not be paid for separately. The work shall be done as per Clause 504 MORTH V revision and as per BOQ provisions.

5.12 Bituminous Concrete

This work shall consist of construction in a single layer of bituminous concrete on a previously prepared Bituminous Macadam (BM) surface. The work shall be done as per Clause 507 MORTH V revision and as per BOQ provisions.

Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-17, for bituminous concrete. The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in **Table-5.12: Composition of Bituminous Concrete** (As per Table 500-17 of MORTH Specifications) and **Table-5.12: Requirement of Bituminous Concrete** (As per Table 500-11: of MORTH Specifications).

Table-5.12: Composition of Bituminous Concrete (As per Table 500-17 of MORTH Specifications)

Grading	1	2
Nominal aggregate size	19 mm	13.2 mm
Layer Thickness	50 mm	30-40 mm
IS Sieve[1] (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix[2]	Min 5.2	Min 5.4

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

3. Job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-19.

Table-5.13: Requirement of Bituminous Concrete
(As per Table 500-11: of MORTH Specifications)

Properties	Viscosity Grade Paving Bitumen	Modified Bitumen		Test Method
		Hot climate	Cold climate	
Compaction level	75 blows on each face of specimen			
Minimum stability (kN at 60 ^{o}C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245
Marshall Quotient (Stability/Flow)	2-5	2.5-5		MS-2 and ASTM D2041
% Air voids	3-5			
% Voids Filled with Bitumen (VFB)	65-75			
Coating of aggregate particle	95% minimum			IS: 6241
Tensile strength ratio	80% minimum			AASHTO T283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 500-12 of MORTH			

5.12.1 Rolling

Immediately after the spreading of mix it shall be thoroughly compacted by rolling with vibratory rollers moving at a speed not more than 5 km per hour. Rolling shall be continued till the mix is thoroughly compacted to meet the general provisions of clauses 501.6 and 501.7.

5.12.2 Opening to Traffic

Traffic shall be allowed on the road after a lapse of minimum 24 hours, preferably 48 hours after laying as approved by the Employer's Representative.

5.13 Quality Control of Road restoration works

5.13.1 General

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to increase the frequencies of tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate Specifications.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the approval of the Engineer.

5.13.2 Tests on Earthwork for Embankment and Subgrade Construction

(i) Sand content [IS:2720 (Part IV)]
1-2 tests per 8000 cu. metres of soil or as per MORTH.

(ii) Plasticity Test [IS:2720 (Part V)]
Each type to be tested, 1-2 tests per 8000 cu. metres of soil or as per MORTH.

(iii) Density Test [[IS:2720 (Part VII)].
Each soil type to be tested, 1-2 tests per 8000 cubic metres of soil or as per MORTH.

(iv) Deleterious Content Test [IS:2720 (PartXXVII)]
As and when required by the Engineer.

(v) Moisture Content Test [IS:2720(Part II)]
One test for every 250 cubic metres of soil or as per MORTH.

(vi) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [IS:2720 (part XVI)]
One test for every 3000 m^3 at least or closer as and when required by the Engineer or as per MORTH.

5.13.3 Compaction control:

Control shall be exercised by taking at least one measurement of density for each 500 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluation a days work on statistical basis. The determination of density shall be in accordance with IS:2720 (part XXVIII). Tests locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 5 as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 gm/cc.

However, for earthwork in subgrade and in top 500 mm portion of the embankment below the subgrade, at least one density measurement shall be taken for every 100 square metres of the compacted area provided further `that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

5.13.4 Tests on Granular Sub base (GSB) and Wet mix macadam (WMM) layers

The tests and their frequencies for the different types of bases and sub-base shall be as given in **Table 5.14**.

Table –5.14: Control Tests and their frequencies for Granular Sub base(GSB) and Wet mix macadam (WMM) layers

Sl.No.	Types of Construction	Test	Frequency***
1.	Granular sub-base	i) Gradation	One test per 200 m^3
		ii) Atterbergs limit	One test per 200 m^3
		iii) Moisture content prior to compaction	One test per 250 m^2
			One test per 500 m^2
		iv) Density of compacted layer	As required
		v) Deleterious constituents	As required
		vi) C.B.R	
2.	Lime/Cement Stabilised	i) Purity of lime (for lime-soil stabilization	One test for each consignment subject to a minimum of one test per 5 tonnes of lime.
		ii) Lime/Cement content	Regularly, through procedural checks.
		iii) Degree of pulverisation	Periodically as considered necessary.
		iv) CBR test on a set of 3 specimens	As required
		v) Moisture content prior to compaction	One test per 250 m^3.
		vi) Density of compacted layer	One test per 500 m^2
		vii) Deleterious constituents	As required
3	Wet mix Macadam	i) Aggregate Impact Value	One test per 200m^3 of aggregate
		ii) Grading	One test per 100 m^3 of aggregate
		iii) Flakiness Index	One test per 200 m^3 of aggregate
		iv) Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 m^3

***** Or as per MORTH**

5.13.5 Tests on Bituminous Constructions

The tests and their frequencies for the different types of bituminous works shall be as given in **Table - 5.15** hereunder.

Table – 5.15: Control Tests and their Frequency for Bituminous Works

Sl. No.	Types of Construction	Test	Frequency
1.	Prime Coat/Tack Coat	i) Quality of binder	As Required
		ii) Binder temperature for a application	At regular close intervals
		iii) Rate of spread of binder	Two tests per day
2	Bituminous macadam (BM) / Bituminous Concrete (BC)	i) Quality of binder	As required
		ii) Aggregate impact value, flakiness index and stripping value of aggregates	One test per 50-100m^3 of aggregate
		iii) Mix-grading	One set of test on individual constituents and mixed aggregates from the dryer for each 100 tonnes of mix subject to a maximum of two sets per plant per day.
		iv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close interval.
		v) Stability of mix (vide ASTM:D-1559)	For each 100 tonnes of mix produced, a set of three Marshall specimens to be prepared and tested for stability, flow value density, and void content, subject to a minimum of two sets being tested per plant per day.
		vi) Binder content and gradation in the mix (Binder content test vide ASTM:D-2172)	One test for each 100 tonnes of mix subject to a minimum of two tests per day per plant.
		vii) Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness.
		viii) Density of compacted layer	One test per 250 m^2 area

5.14 Slab Culvert

Slab culverts shall be constructed at specified locations of the existing cross drainage works as per drawings, or as directed by the Engineer. The Concrete works specifications for construction of RC slab and the rubble masonry specifications for the supporting rubble walls are given in Section-4 and Section-8 respectively and they shall be followed.

5.14.1 Bitumen at Location of Contact

The Bitumen to be used on the top of the bed concrete at the location of contact of RCC slab above in two coats, shall be straight run bitumen of specified grade.

5.14.2 Graded Gravel Free Draining Backfill

On each side of the uncoursed rubble walls supporting the slab culvert a free draining backfill of thickness 200 mm shall be provided. The material for this backfill shall be granular consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be graded and shall meet the grading requirements given in Table 5.16 hereunder.

Table 5.16

Sieve Designation	Percent Passing by Weight
10 mm	100
4.75 mm	30-65
425 microns	5-30
150 microns	0-10

5.14.3 Weep Holes

Weep holes as shown on the drawings or as directed by the Engineer shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of asbestos cement pipes conforming to IS 6908 in rubble walls with necessary M10 concrete cushioning, 75 mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 m c/c and with slope of about 1 vertical to 20 horizontal (or as shown on the drawings) towards the draining face.

5.15 Pipe Drains

Wherever required, pipe drains shall be provided for cross drainage purposes. The sequence of construction shall be as follows:

(a) laying of sand/shingle bedding on the original ground,
(b) laying of PCC of M10 grade,
(c) laying of concrete pipes of NP3 class as per IS 458,
(d) Constructing embankment above in compacted murum, laying of the sub-base and Wet mix Macadam as specified herein above.

The details of above works as directed by Engineer shall be followed.

5.15.1 Materials for Pipe Drains

All materials used in the construction of pipe drains shall conform to the requirements of the Specifications. RCC pipes of NP3 class shall conform to IS 458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by Engineer at the place of manufacture or at site before their incorporation in the Works.

5.15.2 Excavation for pipes

The foundation bed for pipe drain shall be executed true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground in open trenches cut in the existing embankment, taken down to levels as shown in the drawings. Where trenching is involved, its width on either side of pipe shall not be less than 200 mm nor more than one third the diameter of pipe. The sides of the trench shall be as nearly vertical as possible.

When during excavation, the material encountered is soft, spongy or other unstable soil, unless other special construction methods are called for as indicated on drawings, such unsuitable material shall be removed upto a depth of 600 mm or as directed by the Engineer. Before placing any backfill material, exposed surface of the soft soil shall be lightly compacted with one pass of 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive layers of 300 mm and each layer shall be compacted by rolling with a min.0.5 T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions.

When bed rock or boulder strata are encountered, excavation shall be taken down at least 300 mm below bottom level of pipe as directed by Engineer and space filled with approved sand and shingle and thoroughly compacted to provide adequate support for the pipes.

Trenches shall be kept free from water until the pipes are installed and the joints have been hardened. For this purpose, Contractor shall suggest necessary method for diverting the water.

5.15.3 Bedding for pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the pipe drain and shall conform to the specified level and grade.

The pipe shall be bedded in a cradle of concrete having a mix not leaner than M-10. The pipes shall be laid on the concrete bedding before the concrete has set.

5.15.4 Laying of pipes

No pipe shall be placed in position until the foundations have been approved by Engineer. When pipes are to be laid adjacent to each other, they shall be separated by a distance atleast equal to or greater than half the diameter of pipe subject to a minimum of 450 mm.

The laying of pipes on the prepared concrete foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

5.15.5 Jointing

All the joints shall be made with care so that their interior face is smooth and consistent with the interior surface of the pipes. The ends of the pipes should be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

5.15.6 Back filling

Trenches shall be backfilled with selected murum as per specifications given in this part. Backfilling upto 0.3 metre above the top of pipe shall be carefully done and murum shall be thoroughly consolidated under the haunches of the pipe.

5.16 Measurement

5.16.1 Slab Culvert

(a) Measurement of in-situ concrete work shall be as specified in Section 4 of this specification.

(b) Measurement of masonry shall be as specified in Section 8 of this specification.

(c) Bitumen at locations of contact with concrete surface shall be measured in square metres over area covered in plan and the rates shall include cleaning the surfaces, applying in two coats, etc., as specified.

(d) Graded gravel free draining backfill shall be measured in cubic metres and the rate shall include supplying, backfilling, etc., as specified.

(e) Measurement for weep holes shall be running metres and the rates shall include providing and fixing in rubble masonry walls with necessary concrete cushioning to lines and levels as specified.

5.16.2 Pipe Drains

Ancillary works such as excavation, backfilling, laying P.C.C below pipe, etc., shall be paid for separately, as provided under respective clauses.

End of Section-5